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Incidence and frequency of nondental incidental findings on cone-beam computed tomography

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Incidence and frequency of nondental incidental findings on cone-beam computed tomography

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Purpose: The purpose of the present study was to determine the frequency of relevant nondental related incidental findings in cone-beam computed tomography (CBCT) of the head and neck.

Material and methods: Nine hundred ninety-nine images were retrospectively reviewed for incidental findings. Those were defined as carotid artery calcification (CAC), paranasal sinus findings (PSF), sialolithiasis of the parotid gland (SP) or submandibular gland (SSub), calcification of the ligamentum stylohyoideum (CLS), and Stafne bone cavity (SBC). All datasets obtained between 2010 and 2014 at a university-based school of dental medicine in Switzerland were reviewed. Demographic data such as age and sex were also recorded.

Results: A total of 350 incidental findings within the 999 CBCT scans were identified. The most frequent finding was PSF (27.8%), followed by CLS (11.6%), CAC (5.3%), and SSub (0.8%). No SP or SBC was found. Incidental findings were most frequent between 61 and 70 years of age. Males had a higher prevalence in CAC, PSF, and SSub than females.

Conclusions: These results underscore the need for a complete examination of every CBCT image beyond the region of interest.

1. Introduction

Diagnostic imaging of the maxillofacial region substantially improved with the development of cone-beam computed tomography (CBCT). In 1995, Italian coinventors Attilio Tacconi and Piero Mozzo first used this technology in dentistry (Scarfe et al., 2012). In 1999, the NewTom DVT 9000 (QR, Inc., Verona, Italy) was the first commercial CBCT unit to be introduced in Europe (Scarfe et al., 2012).

Since that time, CBCT has become of essential use in dentistry and maxillofacial surgery because of its functionality, which is different from that of medical computed tomography (CT). As the name implies, the beam is cone shaped, which allows the operator to capture a large field of view (FOV). To capture the same FOV in a medical CT scan, in which the beam is fan shaped, the patient has to be scanned in a linear translation movement (Angelopoulos et al., 2012). CBCT provides values that allow visualisation and differentiation between air, water, and soft tissue to a limited extent (Yamashina et al., 2008).

Another advantage of CBCT is its low-dose radiation, compared to medical CT. In a medium FOV (10–15 cm) the effective radiation dose from a multislice computer tomography (MSCT) scan with 0.6 mm voxel size is 1.5–12.3 times greater than that of a CBCT scan with 0.15–0.4 mm voxel size (Ludlow and Ivanovic, 2008). However, the radiation dose is greater in CBCT scans than in panoramic radiography. In one study, the maximum effective doses of two CBCT units were 67 times and 21 times greater than panoramic radiography, respectively (Shin et al., 2014). Despite this, most dental practices use CBCT to image nearly every area of the maxillofacial region, including dentoalveolar dentistry, maxillofacial surgery, orthodontics, implantology, endodontics, periodontics, general dentistry, forensic dentistry, and otolaryngology (De Vos et al., 2009).

Three-dimensional (3-D) visualisation of a region of interest provides information that improves localisation of a pathology and diagnostic accuracy. Patients consequently enjoy better care and treatment outcomes and reduced treatment time and

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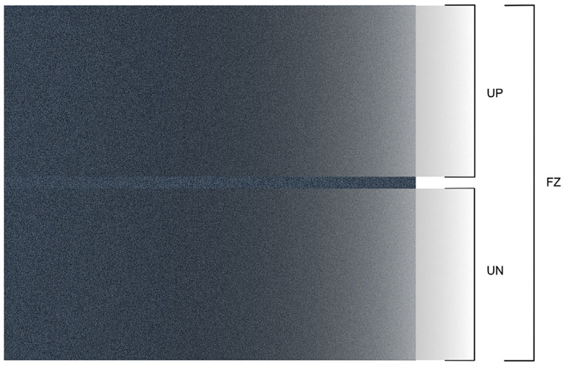
Table 1
FOV.[a]



	Full size	Upper part	Under part	Total
Upper anatomical border	Horizontal line from highest point of sinus maxillaris	Horizontal line from highest point of sinus maxillaris	Horizontal line at point between the two incisors	
Under anatomical border	Horizontal line at C4-C5	Horizontal line at point between the two incisors	Horizontal line at C4-C5	
Number of datasets	442	230	327	999
CAC	X		X	769
PSF	X	X		672
SP	X	X	X	999
SSub	X		X	769
CSL	X		X	769
SC	X		X	769

The FOV[a] of our datasets from our database is different in every scan. For evaluation they were subdivided in full size (442 datasets), upper part (230 datasets) and under part (327 datasets). This table shows how many datasets were evaluated for each finding and in which FOV the findings can be detected.
[a] Field of View: FZ, full size. UP, upper part. UN, under part.

complications (Price et al., 2012). Nevertheless, CBCTs can also be used for a variety of indications, such as calcified anomalies (Lanzer et al., 2015), the anatomy of the retromolar canal (Filo et al., 2015), or for identifying and measuring the alveolar loop (Filo et al., 2014).

Not every practitioner has the skills and the knowledge to detect every pathology in a CBCT image, although a practitioner should be able to interpret a complete image. In addition to a region of primary interest, there could be other important findings that potentially concern a patient's health. Some incidental findings are frequently described in the literature: for example, mucosal thickening and the frequency of paranasal sinus cyst (Drage et al., 2013) or the frequency of carotid artery calcification (Price et al., 2012).

Determining the frequency of incidental findings can improve the knowledge of dental practitioners and allow such practitioners to initiate diagnostic interventions. Patients can be treated early by the right therapy to stop the progression of a disease.

The aim of this retrospective study is to determine the frequency of relevant incidental findings and the age and sex distribution in CBCT imaging. The five incidental findings investigated were carotid artery calcification (CAC), paranasal sinus findings (PSFs), sialolithiasis submandibularis/parotis (SSub/SP), calcification of the stylohyoid ligament (CSL), and Stafne bone cavity (SBC).

2. Material and methods

In this study, 999 CBCT datasets obtained between 2010 and 2014 were reviewed. All datasets were derived from the database of a school of dental medicine in Switzerland. The CBCT datasets were generated by a KaVo 3D eXam CBCT scanner (KaVo Dental GmbH, Biberach, Germany). The following standard settings were used for most datasets: a scan speed of 8.5 s; a rotation of approximately 360°; a voxel size of 0.4 mm; and an x-ray source of high-frequency, constant potential, 90–120 kVp, 3–8 mA (pulsed). The datasets were viewed with the eXam Vision program (KaVo Dental GmbH, Biberach, Germany). The CBCT unit is able to record datasets that vary in vertical dimension (i.e., only the cranial or the caudal part of the head for the primary indication). Thus, for the evaluation, the datasets were separated based on whether they involved the airway area (230 datasets), the cervical area (327 datasets), or both areas (442 datasets) (Table 1).

All 999 datasets were retrospectively reviewed for incidental findings, which were defined as carotid artery calcification (CAC), paranasal sinus findings (PSF), sialolithiasis parotis (SP) and submandibularis (SSub), calcification of ligamentum stylohyoideum (CLS), and stafne bone cavity (SBC). The criteria for identifying these findings are described in Table 2. The datasets were reviewed without provision of any information about the primary indication.

The first examination was executed by a qualified postgraduate with specialised knowledge. The second examination was executed by a qualified associate professor of oral and maxillofacial surgery who specializes in radiology. All provisional positive findings were reanalysed, and their correctness was confirmed or refuted by consensus. To avoid bias, the opinion of the examiner regarding calcification and the patients' medical and dental information were not revealed.

The findings in the predefined areas were checked for bilateralism or unilateralism. Demographic information such as age and sex were also recorded. All data related to the findings were subsequently registered in Excel (Microsoft, Redmond, WA, USA).

Table 2
Diagnostic criteria for identifying the findings.

Diagnosis	Shape	Axial	Coronal	Sagittal
Carotid artery calcification (CAC) (Edwards et al., 2013)	One or more 'rice grains' Linear or curvilinear oblique structures	Cervical soft tissue area Anterolateral to the transverse process Lateral or lateroposterior to the greater cornu of the hyoid bone	Lateral to the anterior tubercle of the cervical spine	Medial and inferior to the angle of the mandible C3 to C5 vertical position
Paranasal sinus findings (PSF)				
Mucosal thickening	A light continuous homogenous radio opacity measured by the distance (>3 mm) between the air-mucosal interface and the inner bony margins of the sinus (Raghav et al., 2014)	Sinus maxillaris	Sinus maxillaris	Sinus maxillaris
Sinus cyst	Smooth, outwardly convex soft tissue mass on imaging (Raghav et al., 2014)	Sinus maxillaris	Sinus maxillaris	Sinus maxillaris
Sialolithiasis (SSub/SP)				
Submandibularis (Benson, 2009)	Long cigar-shaped to oval or round Homogeneous radiopaque internal structure, when visible	Anterolateral or anterior to the airway space	Medial to the mandible under the occlusion level	Medial to the mandible under the occlusion level
Parotis (Benson, 2009)	Same as sialolithiasis submandibularis	Lateral, anterolateral, or anterior to the ramus mandibulae	Between the occlusion level and the zygomatic arch	Between the occlusion level and the zygomatic arch
Calcification of the ligamentum stylohyoideum (CLS) (Carter, 2009)	Elongated styloid process: long, tapering, thin, radiopaque; thicker at its base and projects anterior and caudal; length > 30 mm	Lateral-posterior to medial-anterior	Medial to the mandible Anterior to the anterior tubercle of the spine	Vertical position from skull base to hyoid bone
	Calcified ligament: homogenously radiopaque, straight outline, sometimes an irregularity in the outer surface, can build interruptions (i.e., the so-called 'pseudoarticulations')	Medial to the mandible	Lateral to airway space	Progress of calcification is anterior-caudal
Stafne bone cavity (SBC)	Well-defined round or ovoid radiolucency with a diameter of 1–3 cm (Murdoch-Kinch, 2009)	An opening in the lingual margin of the mandible (Slasky and Bar-Ziv, 1996). In rare cases, the buccal part can be involved (Philipsen et al., 2002)	An opening in the lingual cortex of the mandible caudal to the mandibular canal. May involve the inferior border of mandible (Murdoch-Kinch, 2009)	Often in the angle of the mandible in the region of the antegonial notch and submandibular gland fossa (Murdoch-Kinch, 2009)

Descriptive statistical analysis was performed by using SPSS (IBM, Armonk, NY, USA). Parametric data were expressed as mean and standard deviation (M [SD]). Descriptive statistical analysis was used, and statistical significance level was defined at $p < 0.05$. A Chi-Square test was used to compare age and gender with each finding, and a Bonferroni post hoc test was used for further statistical analysis.

The ethics review committee of Zürich reviewed and approved the study protocol (KEK-ZH-Nr: 2014-0680). The Guidelines of the Declaration of Helsinki concerning ethical principles for medical research involving human subject were observed.

3. Results

Of the 999 CBCT scans, there was a preponderance of females. 53.8% were female subjects and 46.2% were male subjects. The age range was 6–92 years, and the median age was 42 years.

We detected a total of 350 incidental findings in the 999 CBCT scans. The finding with the highest prevalence was PSF (27.8%), followed by CLS (11.6%), CAC (5.3%), and SSub (0.8%). For better illustration, the prevalence results have been grouped in Table 3. SP and SBC were not found. PSF is presented in Fig. 3 as mucosal thickening (MT). Concerning the sex-related prevalence, only CLS were more prevalent in females, whereas in the other findings (CAC, PSF, SSub) males had a higher prevalence than females.

Bilateral findings were detected more in CLS. The other three findings (CAC, PSF, SSub) had more unilateral findings. Fig. 4 demonstrates a CSL with so-called pseudoarticulation. The side distribution for SSub was equal with three findings on each side. A right-sided SSub is shown in Fig. 5, with a sialolith located in the submandibular duct.

Incidental findings were most frequent in the 61-year-old–70-year-old age group (CAC, PSF, CLS) and in the 11–20 year-old age group (SSub). Fig. 1 shows the distribution of the findings. The median age for CAC is 67 years, which is highest median age. However, female subjects with CAC findings had a higher median age than male subjects. The lowest median age is 37.5 years, for SSub. The age distribution of each finding is represented in Table 4.

In addition, patients without CAC were significantly younger ($p = 0.002$) than patients with CAC. Fig. 2 shows a CAC, which was detected during examination.

4. Discussion

The aim of this study was to evaluate the prevalence of sex-related and age-related incidental findings in CBCT. The results of this study demonstrate that general practitioners should be aware of the fact that incidental findings in the head and neck region in CBCT are frequent. A review from Edwards et al. (2013) confirmed this statement. By evaluating the prevalence of incidental findings in CBCT datasets, the knowledge of dentists regarding early diagnostic investigations can be improved. Patients with concerning findings could thereby begin the correct therapy earlier in order to prevent the progression of the disease. The dental practitioner, who takes the CBCT image, is responsible for identifying every finding, because correct documentation in a medical profession is indispensable. Many of the chosen findings are also seen in panoramic

Table 3
Frequency of findings.

		Male	Female	Total
CAC[a]	Left	2	6	8 *(1.0%)*
	Right	11	11	22 *(2.7%)*
	Bilateral	7	4	11 *(1.4%)*
	Total	20 *(2.6%)*	21 *(2.7%)*	**41 *(5.3%)***
PSF[b]	Left	33	26	59 *(8.8%)*
	Right	46	38	84 *(12.5%)*
	Bilateral	21	23	44 *(6.5%)*
	Total	100 *(14.9%)*	87 *(12.9%)*	**187 *(27.8%)***
SSub[c]	Left	2	1	3 *(0.4%)*
	Right	2	1	3 *(0.4%)*
	Bilateral	0	0	0 *(0.0%)*
	Total	4 *(0.5%)*	2 *(0.3%)*	**6 *(0.8%)***
CLS[d]	Left	12	7	19 *(1.9%)*
	Right	3	7	10 *(1.0%)*
	Bilateral	34	53	87 *(8.7%)*
	Total	49 *(4.9%)*	67 *(6.7%)*	**116 *(11.6%)***

The data are presented as the number (percentage). The percentages refer to the number of findings per number of scans on that side.
CAC, carotid artery calcification.
[a] The information is based on 769 (347 male, 422 female) cone-beam computed tomography scans (i.e., datasets of cervical area and both [cervical and airway] areas).
[b] Information is based on 672 (312 male, 360 female) cone-beam computed tomography scans (i.e., datasets of the airway and both [cervical and airway] areas). PSF, paranasal sinus findings.
[c] The information is based on 769 (347 male, 422 female) cone-beam computed tomography scans. SSub, sialolithiasis submandibularis.
[d] The information is based on 999 (462 male, 537 female) cone-beam computed tomography scans (i.e., all areas). CLS, calcified ligamentum stylohyoideum.

images (Ariayi et al., 2009). Reliable data from the percentage of the findings in the literature are rare. We used 999 patients, whereas other studies used less; so, there is a variation of sample sizes in the literature (Edwards et al., 2013). A bigger sample size represents better information about the whole population. Furthermore, the quality of CBCT resolution is improving every year. Before CBCT launched, panoramic radiography was the standard. Now we can use CBCT images, and can do so with much better quality. We expect that the differentiation of radioopacities in newer CBCT images will be more effective than that in old CBCT images. This means that older studies should be interpreted with caution. For the evaluation of incidental findings, the appearance of incidental findings in radiographic images should be standardized. Studies that can be performed with the same methods and data will be more reliable. Moreover, the comparability of such will increase, because there is a better chance for the examiner to evaluate the same incidental finding.

For a dental general practitioner, it is difficult to decide what to do in case of an incidental finding. For example, atherosclerosis needs further clinical information, such as blood pressure, for an examiner to decide its acuteness (MacDonald et al., 2012). He or she is not confronted with such findings in everyday practice. We expect that, in most cases, the examiner would send the patient to an oral surgeon or general physician. However, up

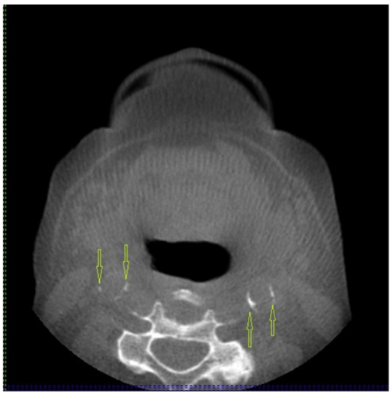


Fig. 2. The axial cone-beam computed tomography image shows bilateral carotid artery calcification (CAC) (arrows).

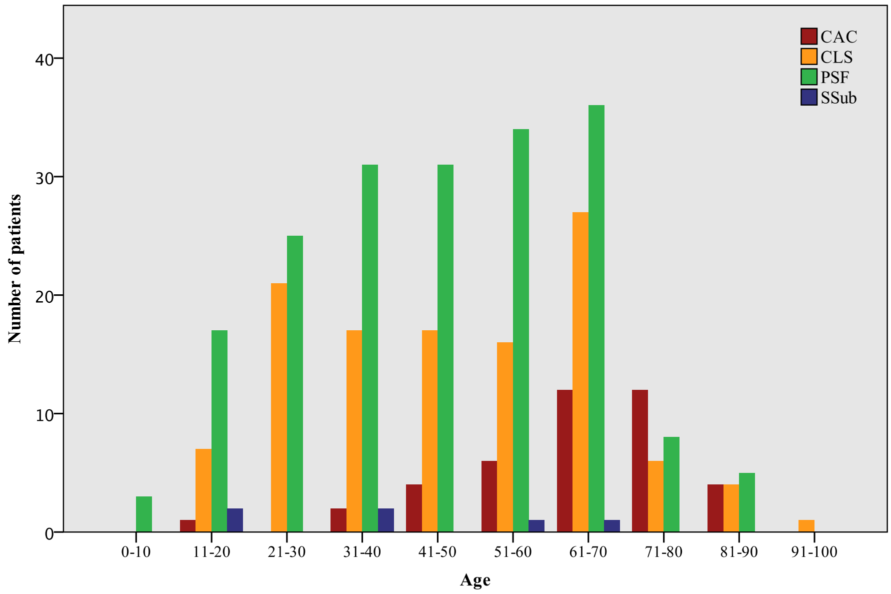


Fig. 1. Distribution of all findings by age group. The 61–70-year-old age group had the most incidental findings. The youngest patient with a positive finding was 7 years old and the oldest patient was 91 years old. CAC, carotid artery calcification; CLS, calcification of the stylohyoid ligament; PSF, paranasal sinus findings; SSub, sialolithiasis submandibularis.

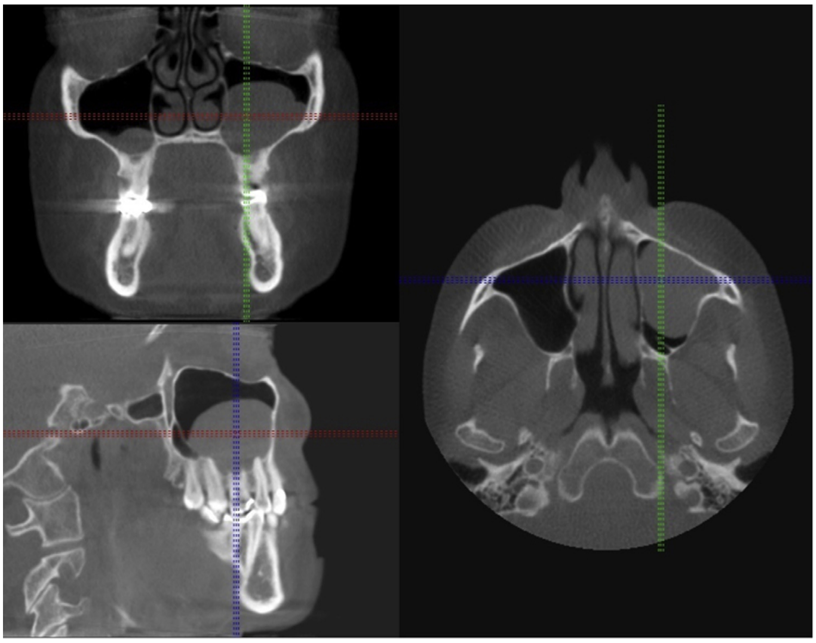


Fig. 3. Cone-beam computed tomography images (coronal, sagittal and axial) demonstrate bilateral mucosal thickening (MT). The relationship between the tooth (26) and MT should be discussed and further clinical investigations should be performed.

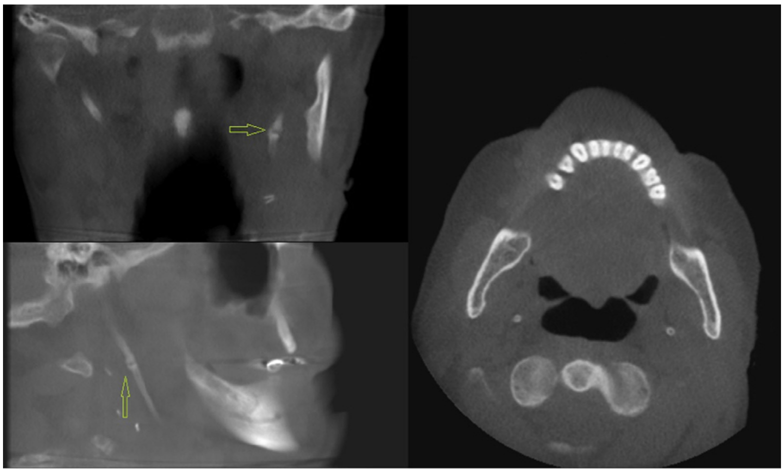


Fig. 4. Cone-beam computed tomography images (coronal, sagittal and axial) demonstrate bilateral calcification of the stylohyoid ligament (CSL), building 'pseudoarticulation' (arrow). Clinical investigations should be performed to exclude Eagle syndrome.

to the present, there are no existing mandatory therapeutic interventions for either one of the findings. To gain more certainty in therapeutic interventions for general dental practitioners, further studies with a focus on clinical aspects should be performed—which was our drawback. Subsequently, the importance of each finding could be evaluated, and patients could get reliable treatment.

Nearly all frequencies mentioned in this section are data from CBCT studies. The results of this study should be interpreted with caution due to their retrospective character, and a prospective study should be performed to gain more certainty.

4.1. Carotid artery calcification (CAC)

In our study, the prevalence of CAC was 5.3%. Other studies that examined the prevalence of CAC reported findings ranging from 1.5% to 43% (Allareddy et al., 2012; Damaskos et al., 2015; Price et al., 2012). This variation shows the potential difficulty of

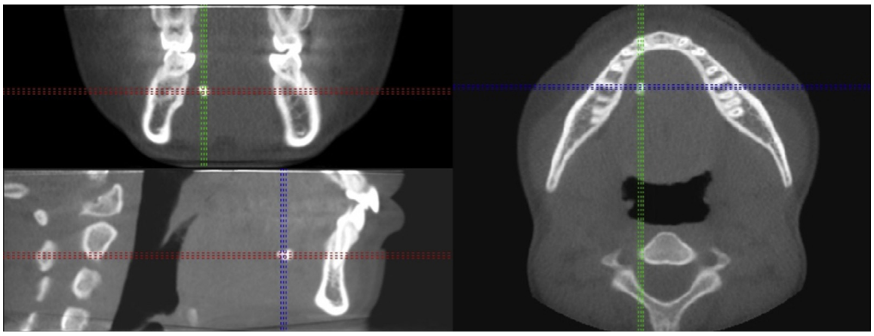


Fig. 5. Cone-beam computed tomography images (coronal, sagittal, and axial) demonstrate right-sided sialolithiasis submandibularis. The sialolith is located in the Wharton duct.

Table 4
Age distribution of the findings.[a]

	Median	Median male	Median female	Minimum	Maximum
CAC	67	65.5	68	19	89
PSF	46	45.5	47.5	7	90
Ssub	37.5	37.5	35	16	61
CSL	48	53	46	16	91

CAC, carotid artery calcification. PSF, paranasal sinus findings SSub, sialolithiasis submandibularis. CLS, calcified ligamentum stylohyoideum.
[a] The data are presented as the number (years).

diagnosing CAC. Many other calcifications and structures can be found in this area of the head, and these are not easy to differentiate from CAC. One such structure is known as the ‘triticeous cartilage’, which is the cartilage located in the lateral thyrohyoid ligament at the C3–C4 vertical position. Another such structure is the superior cornu of the thyroid, which can also be misdiagnosed as CAC (Ahmad et al., 2005). In our opinion, the result can also be biased by calcifications, such as calcified lymph nodes, CSL, or tonsil stones. Men have a greater risk of atherosclerosis compared to women; therefore, we expected to observe more CAC findings in men (Böcker et al., 2012). Accordingly, this was reflected in our study: the prevalence of CAC in women was slightly lower than that in men. Furthermore, unilateral findings were more frequent than bilateral findings in our study, whereas a recent paper reported more bilateral findings (Damaskos et al., 2015). In this study, most CACs were found in 61-year-old to 80-year-old patients, which is consistent with previous studies reporting the detection of more CACs in patients older than 60 years (Damaskos et al., 2015; Pette et al., 2012). Therefore, our study emphasises that patients without CAC tend to be significantly younger than patients with CAC.

4.2. Paranasal sinus findings (PSF)

In our sample, the prevalence of PSF was 27.8%—the most frequent. This study included MT greater than 3 mm as well as sinus cysts, because these findings are the most common (Edwards et al., 2013). Other studies that utilised CBCT to analyse the same type of findings reported a range of 10.7%–85.8% (Edwards et al., 2013; Lana et al., 2012), thereby demonstrating the large variation in the reported ranges for these findings. One reason for this variation may be the different definition of MT. In our study, males had more paranasal findings than females, and this observation is supported by other studies (Raghav et al., 2014; Ritter et al., 2011). However, these studies included more paranasal pathologies in their recruitment. Nonetheless, a previous paper reported that women had significantly more MT and sinus cysts compared to men (Allareddy et al., 2012). Thus, gender distribution is not clear in the literature. Our population had more right-sided findings, consistent with several published papers (Raghav et al., 2014; Ritter et al., 2011). The age range of parasinus findings was 7–90 years, indicating no preference for a particular age group; further, the median age was 43 years, and other studies confirm this finding (Lana et al., 2012; Raghav et al., 2014).

4.3. Calcification of the stylohyoid ligament (CSL)

In the literature, the prevalence of CSL ranges from a low value of 3.1% to a high value of 63.3% (Edwards et al., 2013; Mahdian et al., 2014). This high value may result from the high mean age in at least one of these studies (Mahdian et al., 2014). In this study, we observed a prevalence of 11.6%, and the median age was 48 years; moreover, we observed that CSL occurred in all of the age groups, with a higher distribution of the values in the older age group (i.e., 61–70 years). A recent paper showed that females experience CSL more frequently than males, and that bilateral CSL is more frequent than unilateral CSL (Mahdian et al., 2014). Our study confirms this observation. For evaluation, we used calcification as well as elongation of the ligamentum stylohyoideum, because both may lead to symptoms (Mahdian et al., 2014). We did not pay attention to the patients' symptoms because we did not evaluate the patients' medical information. However, some patients with CSL developed symptoms of the so-called ‘eagle syndrome’: a variety of symptoms involving cranial nerves V, VII, IX, and X. A patient can experience ear and neck pain, dysphagia, odynophagia, persistent sore throat, or the sensation of a foreign body in the pharynx. In most cases, the patients have unilateral symptoms (Piagkou et al., 2009). The cause is not yet well understood (Murtagh et al., 2001).

4.4. Sialolithiasis parotis and submandibularis (SP and SSub)

In the literature, the prevalence of sialoliths in CBCT ranges from 0.4% to 1% without regard to information about the differentiation of sialoliths in the submandibular gland or the parotid gland (Allareddy et al., 2012; Edwards et al., 2013). Sialoliths occur more often in females as an incidental finding in CBCT (Allareddy et al., 2012), although the condition itself appears to be more common overall in males (Ledesma-Montes et al., 2007). However, we did not find this to be predominant in either sex in this study. Sialolithiasis can appear at any age (Huang et al., 2009; Mandel and Hatzis, 2000), with rare cases being reported in children (Bodner and Fliss, 1995). Parotid duct stones are smaller than submandibular stones and occur more frequently in the third and fourth decades of life (Mandel and Hatzis, 2000). We found no parotid sialoliths in this study, and the incidence of these sialoliths is reportedly small, in 10%–20% of all sialoliths (Kesse et al., 1998). The high concentrations of calcium and phosphate and the more viscous mucous content of saliva cause more sialoliths in the submandibular gland (Huang et al., 2009). However, as a diagnostic tool, 3-D imaging is a significant aid in identifying parotid stones (Mandel and Hatzis, 2000).

4.5. Stafne bone cavity (SBC)

In this study, no SBC was found; one reason may be the low prevalence of the finding, which ranges between 0.08% and 0.4% (Allareddy et al., 2012; Assaf et al., 2014; Correll et al., 1980; Price et al., 2012). Additionally, a reason may be that the finding appears more often in male patients and at a mean age of 45–60 years (Allareddy et al., 2012; Correll et al., 1980; Murdoch-Kinch, 2009; Schneider et al., 2014a; Shimizu et al., 2006). One study reported that no changes occurred in adults after several years of follow-up (Philipsen et al., 2002), whereas another study indicated that an SBC may expand until it reaches a mature stage in younger patients (Hansson, 1980). General practitioners should follow-up on radiographic images; the findings must be differentiated from bony lesions, which need treatment (Philipsen et al., 2002). In one study, magnetic resonance imaging (MRI) showed that the cavity was filled with glandular, lymphoid, and adipose tissue (Schneider et al., 2014a). Moreover, a recent case report showed that diagnosis could finally be made just with an MRI (Schneider et al., 2014b).

5. Conclusion

This study showed the different frequencies of four incidental findings (CAC, PSF, SSub, and CLS) in CBCT datasets, emphasising the need for a complete examination of every scan. The prevalence of these findings varies according to their nature; therefore, dental practitioners must be aware of the frequency and location of these findings and must further investigate any that are clinically important beyond the primary region of interest. Up to now, we do not have any reliable data for relevant incidental findings and mandatory therapeutic interventions. Studies with a clinical focus should be performed to gain more knowledge of therapeutic interventions for general dental practitioners. Relevant incidental findings should be mentioned to students and should be included in further education for dentists to improve awareness for clear appraisal and identification in every CBCT image.

Conflict of interest

None.

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